Reverberation and Inversion in Shallow-Water

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LONG-TERM GOALS

The long-term goals of this research is to provide a proper way of extracting the modal back-scattering matrix **Θ**mn from the reverberation data in shallow-water based on full-wave theory. Specially, we relax the Lambert law assumption or the separable scattering assumption . Our inversion is based on a general acceptable reverberation model. The result of the extracting **Θ**mn will provide a better understanding of the mechanism of bottom back-scattering in modal space.

OBJECTIVES

The objectives of this research are: a) to develop the method of extracting the modal back-scattering matrix **S**mn from the reverberation data in shallow-water, b) to analysis the adiabaticity of acoustic propagation in shallow-water so we can identify the conditions that the modal back-scattering matrix is induced by bottom-interaction only, and the volum-interaction is not involved.

APPROACH

In shallow-water it is suitable to develop the reverberation model based on normal mode theory, and this has been done since early 1960-1970 [1-3], and the recent progress can be found in [4,5]. Now, the acceptable model of reverberation in shallow-water consists three components : { propagation from source to scatterers } {scattering at the scatterers} {propagation from scatterers to receivers}, within the adiabatic mode and perturbation regime , the analytic representation of these three components can be derived.

The key component is the scattering components which is described by the back-scattering matrix **Θ**mn, and how to extract this matrix from the reverberation data become an attractive but difficult issue. There are ,indeed, some works deal with the extracting of **Θ**mn from reverberation data [6-9]. However, the inversion are based on either ***empirical*** law (Lamberts law) or an ***assumption*** of separable matrix as

$$\mathbf{\Theta}mn = \mathbf{\Theta}m\,\mathbf{\Theta}n$$

There are many cases that have marked departure from Lamberts law [10], and the assumption of separable matrix is not adequate in general [11].

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14. ABSTRACT
The long-term goals of this research is to provide a proper way of extracting the modal back-scattering matrix Omn from the reverberation data in shallow-water based on full-wave theory. Specially, we relax the Lambert law assumption or the separable scattering assumption . Our inversion is based on a general acceptable reverberation model. The result of the extracting ??mn will provide a better understanding of the mechanism of bottom back-scattering in modal space.

15. SUBJECT TERMS

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We propose new approaches to extract **Θ**mn from the reverberation data without any ***a priori*** assumption on scattering :

Approach 1: Mode-selective source array with mode-filtering receiving array.

As we know that the reverberation is represented by double summation of modes, the inversion is extremely ill-posed. The mode-selective source array reduces the double summation to a single summation, and the mode-filtering receiving array makes the inversion unique. This is the ideal approach but it is expensive, a perfect source array is not often available.

Approach 2: Changing point source depth with mode-filtering array.

The reverberation intensity received by a model-filtering array is a single summation over limited effective modes, and the kernel matrix is a function of source depth, by changing the source depth properly, the kernel matrix can be regular and the inversion will not be illposed.

Approach 3 : Sequential inversion based on the mode stripping in waveguide.

Due to the mode stripping in shallow-water waveguide, the sequential inversion can be done with the lowest mode at the longest distance. Due to the symmetry of the kernel matrix the inversion can be done for just a single source depth. This is very useful for higher frequency data analysis.

WORK COMPLETED

Theoretical analysis has been completed, some numerical simulations have been done.

RELATED PROJECTS

The approaches proposed in this research are closely related to ASIAEX bottom-interaction data analysis.

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PUBLICATIONS

One paper : “Extraction of modal back-scattering matrix from reverberation data in shallow-water waveguide.Part I- Theory,” has been submitted to the *Proceedings of ICTCA2001*.